



**Suitable Applications (cont.)**

Infiltration systems should typically be designed for off-line use to capture the first flush of runoff. A diversion structure such as a flow splitter or weir may be necessary to separate and route the first flush to the infiltration system for water quality control, and route the remaining stormwater to a water quantity device downstream. Infiltration systems are most effective when turbulent flow is minimized and the flow is spread uniformly across the filter media.

**Feasibility Criteria**

The following feasibility criteria should also be considered:

- To be suitable for infiltration, underlying soils shall have an infiltration rate (f) of 0.52 inches per hour or greater, as initially determined from NRCS soil textural classification and subsequently confirmed by field geotechnical tests. The recommended geotechnical testing is one test hole per 5000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility).
- Soils should have a clay content of less than 20% and a silt/clay content of less than 40%.
- Infiltration cannot be located on slopes greater than 15% or within fill soils.
- To protect groundwater from possible contamination, runoff from designated hotspot land uses or activities should not be infiltrated without proper pretreatment to remove hydrocarbons, trace metals, or toxicants.
- Infiltration systems should be constructed with a minimum of 4 feet distance between its base and the water table or bedrock to allow for infiltration to occur. Care must especially be taken in karst areas, where the potential for groundwater contamination and sinkhole collapse should be considered. If a site overlies karst geology, additional geotechnical investigation should be undertaken and the local approval authority should be consulted for specific design requirements.
- Infiltration facilities should be located at a minimum of 100 feet horizontally from any water supply well.
- The maximum contributing area to an individual infiltration practice should generally be less than 5 acres.
- Infiltration practices should not be placed in locations that cause water problems to downgrade properties. Infiltration facilities should be set back 25 feet (10 feet for dry wells) down gradient from structures.

**Approach****➤ Infiltration Trench**

An infiltration trench is ideal for linear applications, and is most effective when preceded by a pretreatment series such as a swale and stormwater pond. From here, runoff is conveyed into the trench where it is stored in the voids between pea gravel. Treatment occurs as water seeps through the soil. This practice requires verification of soil permeability and contributes to groundwater recharge. If used without proper pretreatment devices, the longevity of this practice may be less than 5 years, and should therefore not be constructed as an independent treatment mechanism. This practice is also not appropriate to serve hotspot applications due to the propensity for groundwater contamination. The maximum drainage area for this practice is 5 acres, with a maximum of 15% slope.

**Approach  
(cont.)**

➤ **Infiltration Basin**

An infiltration basin is a shallow basin designed to treat runoff through infiltration of soil. Like the infiltration trench, this practice is most effective when coupled with pretreatment practices such as filter strips or grass channels. This practice requires verification of soil permeability and has high maintenance requirements to prevent clogging. Although this practice does not utilize an outlet, a backup underdrain pipe is incorporated to relieve ponded water that has not infiltrated over long periods of time. Drawbacks to the use of infiltration basins are a high failure rate, and frequent maintenance to maintain soil permeability.

**Design Criteria**

**Infiltration Conveyance Criteria**

- A conveyance system shall be included in the design of all infiltration practices in order to ensure that excess flow is discharged at non-erosive velocities.
- The overland flow path of surface runoff exceeding the capacity of the infiltration system shall be evaluated to preclude concentrated flow that causes erosion. If computed flow velocities do not exceed the non-erosive threshold, overflow may be accommodated by natural topography.
- Infiltration systems should be designed to fully de-water the entire  $WQ_v$  within 48 hours after the storm event.

**Infiltration Pretreatment Criteria**

To ensure the long term effectiveness of infiltration systems, preventative measures should be taken to minimize clogging. Pretreatment is generally most effective when multiple BMPs are placed in series. These may include vegetated filter strips, swales, sedimentation basins, or sediment traps.

**Pretreatment Volume**

- A minimum of 25% of the  $WQ_v$  must be pretreated prior to entry to an infiltration facility. If the infiltration rate for the underlying soils is greater than 2.00 inches per hour, 50% of the  $WQ_v$  shall be pretreated prior to entry into an infiltration facility. This can be provided by a sedimentation basin, stilling basin, sump pit or other acceptable measures. Exit velocities from pretreatment shall be non-erosive during the two-year design storm. The Camp-Hazen equation may be used as an acceptable alternative for determining infiltration pretreatment requirements. The Camp-Hazen equation accounts for the effects of turbulent flow to compute the required minimum surface area for pretreatment,  $A$ :

$$A_s = \frac{Q_o}{W} \times E'$$

Where:

$A_s$  = sedimentation basin surface area (ft<sup>2</sup>)

$Q_o$  = discharge rate from basin =  $(WQ_v) / (24 \text{ hr})$

$W$  = particle settling velocity (ft/s); for percent impervious,  $I \leq 75\%$ , use

$W = 0.0004 \text{ ft/s}$ , for  $I > 75\%$ , use  $W = 0.0033 \text{ ft/s}$

$E'$  = sediment trapping efficiency constant; for sediment trapping efficiency,  $E$ , of 90%,  $E' = 2.30^2$

**Design Criteria  
(cont.)****Pretreatment Techniques to Prevent Clogging**

Each system shall have redundant methods to protect the long term integrity of the infiltration rate. The following techniques, at least three per trench and two per basin, should be installed in infiltration systems:

- Grass channel
- Grass filter strip (minimum 20 feet and only if sheet flow is established and maintained)
- Bottom sand layer
- Upper sand layer (6" minimum) with filter fabric at the sand/gravel interface.
- Use of washed bank run gravel as aggregate

The sides of infiltration trenches should be lined with an acceptable filter fabric that prevents soil piping but has greater permeability than the parent soil.

**Infiltration Treatment Criteria**

- Infiltration practices should be designed to exfiltrate the difference between the  $WQ_v$  minus the exfiltration volume. Infiltration practices are best used in conjunction with other BMPs and often downstream detention is still needed to meet the  $Cp_v$  and  $Q_p$  sizing criteria. Experience has shown that the longevity of infiltration practices is strongly influenced by the care taken during construction.
- A porosity value "n" ( $n=V_v/V_t$ ) of 0.40 should be used in the design of stone reservoirs for infiltration systems.

**Infiltration Landscaping Criteria**

- Establish a dense and vigorous vegetative cover over the contributing pervious drainage areas before runoff can be accepted into the facility. Infiltration trenches should not be constructed until the contributing drainage area has been completely stabilized.
- An infiltration trench should have a 2 to 10 foot excavation lined with a sand base beneath filter fabric and filled with coarse stone aggregate. The surface layers should consist of filter fabric and a layer of 2 inch pea gravel (See Figures PTP-05-01 and PTP-05-02). The empty spaces between the stones provide temporary storage for runoff as it filters through the soil at the bottom of the trench.
- An infiltration basin is typically 3 to 12 feet in depth with a maximum depth dependant on soil type. Basins should be designed to hold runoff from the design storm. Drainage areas range from 5 to 10 acres, with slopes less than 15%. The basin itself should be located at least 50 feet away from slopes greater than 20%. An emergency spillway should be provided to direct overflows from storms exceeding the design storm capacity.

**Design Criteria  
(cont.)****Infiltration Maintenance Criteria**

- Infiltration practices should not be used for a sediment control device during the site construction phase.
- A perforated pipe should be installed in the infiltration trench to monitor water levels and drawdown time. The pipe should be flush with the bottom of the trench. An anchored six-inch diameter perforated PVC pipe with a lockable cap is recommended for the observation well.
- It is recommended that infiltration designs include dewatering methods in the event of failure. This can be done with underdrain pipe systems that accommodate drawdown.
- Direct access should be provided to all infiltration practices for maintenance and rehabilitation.
- Infiltration practices should not be covered by an impermeable surface.

**Maintenance**

When not properly maintained, infiltration systems have a high failure rate. Maintenance and inspections should be conducted regularly to ensure the long term functionality of the system.

An observation well should be installed in trenches to determine how quickly it drains after a storm event and to observe sediment buildup.

**Semi-Annual Maintenance**

- Check observation wells following 3 days of dry weather (failure to infiltrate within this time indicates clogging).
- Inspect pretreatment devices and diversion structures for sediment buildup and structural damage

**Standard Maintenance**

- Remove sediment and oil/grease from pretreatment devices and outflow structures

**5-Year Maintenance**

- If bypass capability is available, utilize to provide an extended dry period. This may allow the system to regain the infiltration rate in the short term.

**Upon Failure**

- Total rehabilitation of the system to maintain storage capacity.
- Excavate trench walls to expose clean soil.



**Infiltration Trench**

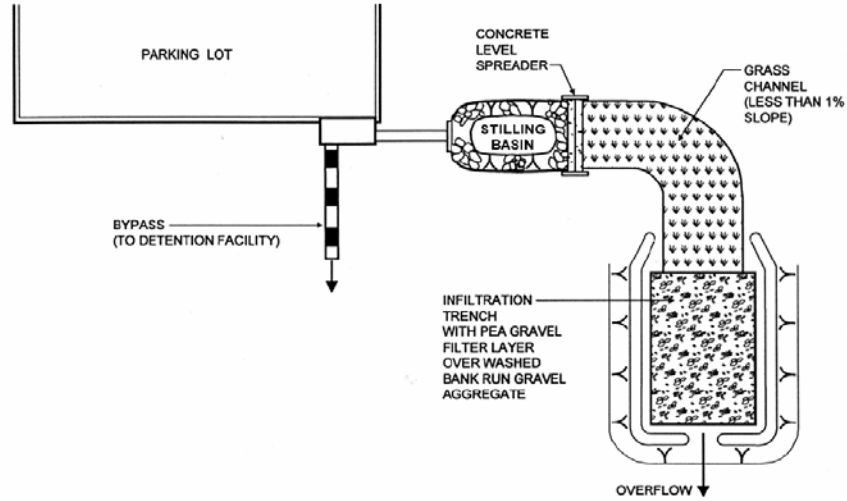
Source, Stormwater Managers Resource Center, [www.stormwatercenter.net](http://www.stormwatercenter.net)



**Infiltration Trench**

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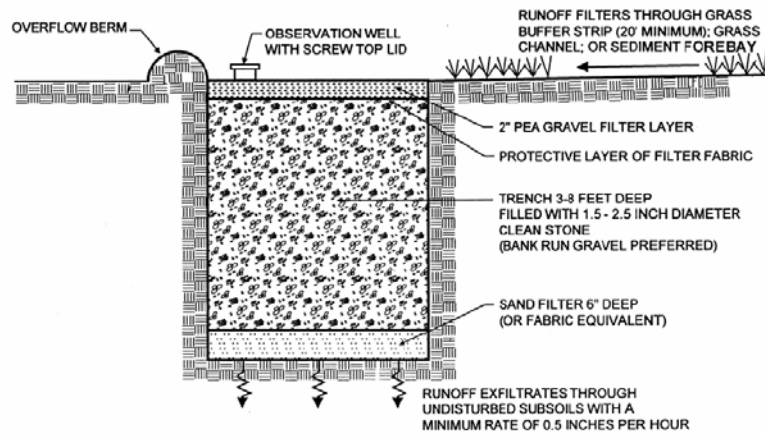
Infiltration Trench



PLAN VIEW

Figure PTP-05-01

Source: Maryland Stormwater Design Manual



PROFILE

Figure PTP-05-02

Source: Maryland Stormwater Design Manual



**Infiltration Basin**

Source, *Stormwater Managers Resource Center*, [www.stormwatercenter.net](http://www.stormwatercenter.net)

Infiltration Basin

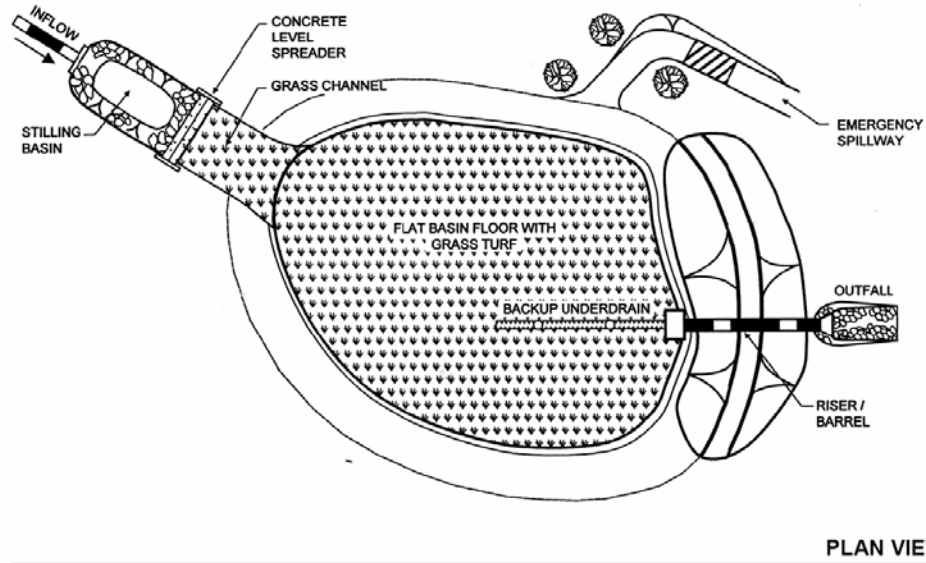


Figure PTP-05-03

Source: Maryland Stormwater Design Manual

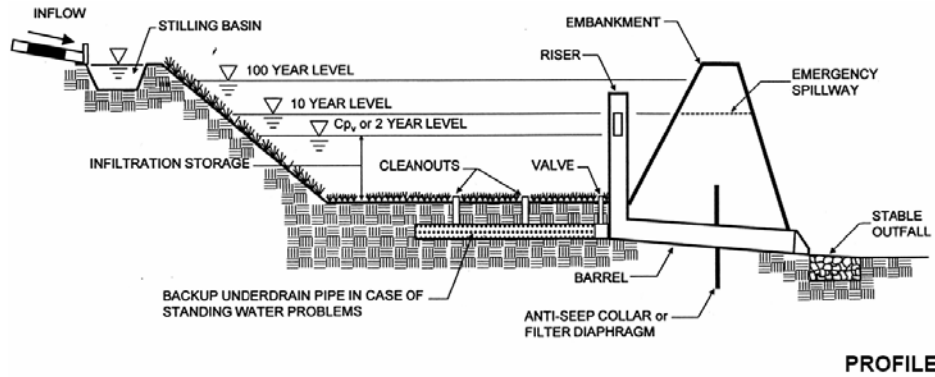


Figure PTP-05-04

Source: Maryland Stormwater Design Manual

**Infiltration  
Trench Design  
Procedures****Infiltration Trench Design Procedures**

**Step 1.** Compute runoff control volumes.

Calculate the Water Quality Volume ( $WQ_v$ ), Channel Protection Volume ( $Cp_v$ ), Overbank Flood Protection Volume ( $Q_p$ ), and the Extreme Flood Volume ( $Q_f$ ).

**Step 2.** Determine if the development site conditions are appropriate for the use of an infiltration trench.

- Type of development?
- Permeable subsoils?
- Low water table?
- Low sediment load?
- Karst area?

**Step 3.** Confirm local design criteria and applicability

Consider any special site-specific design conditions/criteria (Additional Site-Specific Design Criteria and Issues). Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

**Step 4.** Compute  $WQ_v$  peak discharge ( $Q_{wq}$ ).

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion.

- Using  $WQ_v$  (or total volume to be infiltrated), compute CN
- Compute time of concentration using TR-55 method
- Determine appropriate unit peak discharge from time of concentration
- Compute  $Q_{wq}$  from unit peak discharge, drainage area, and  $WQ_v$ .

**Step 5.** Size flow diversion structure, if needed

A flow regulator (or flow splitter diversion structure) should be supplied to divert the  $WQ_v$  to the infiltration trench.

Size low flow orifice, weir, or other device to pass  $Q_{wq}$ .

**Infiltration  
Trench Design  
Procedures  
(cont.)****Step 6. Size infiltration trench**

The area of the trench can be determined from the following equation:

$$A = (WQ_v) / (nd + kT/12)$$

Where:

- A = Surface Area
- $WQ_v$  = Water Quality Volume (or total volume to be infiltrated)
- n = porosity
- d = trench depth (feet)
- k = percolation (inches/hour)
- T = Fill Time (time for the practice to fill with water), in hours

A porosity value  $n = 0.32$  should be used. All infiltration systems should be designed to fully dewater the entire  $WQ_v$  within 24 to 48 hours after the rainfall event. A fill time  $T=2$  hours can be used for most designs.

**Step 7. Determine pretreatment volume and design pretreatment measures.**

Pretreatment facility should be sized to treat 25% of the water quality volume ( $WQ_v$ ) for off-line configurations.

**Step 8. Design spillway(s).**

Adequate stormwater outfalls should be provided for the overflow exceeding the capacity of the trench, ensuring nonerosive velocities on the down-slope.